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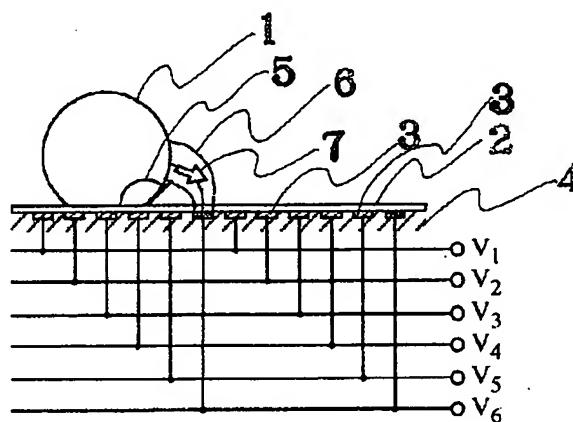
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## (54)【発明の名称】液体微粒子ハンドリング装置

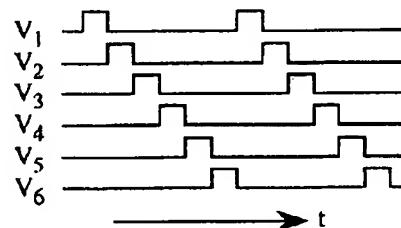
## (57)【要約】

【課題】試料および試薬を疎水性表面上の液滴の形で扱い、これらを静電力で駆動することにより、バルブ・ポンプのいらない極微量化学反応および分析装置を構成する。

【解決手段】基板上に電極列を設け、この上に疎水性表面処理をする。試料および試薬を液滴化してこの表面上に置き、電極に印加する電圧を順次切り替えていくことにより、液滴を輸送する。反応は2つの液滴を衝突させて混合させることにより行う。分岐を作れば粒子を振り分けることができる。バルブ・ポンプなどの不要な簡単な構造で極微量化学反応および分析装置が実現できる。



タイミングチャート



# PATENT ABSTRACTS OF JAPAN

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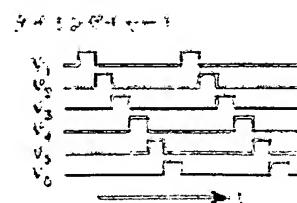
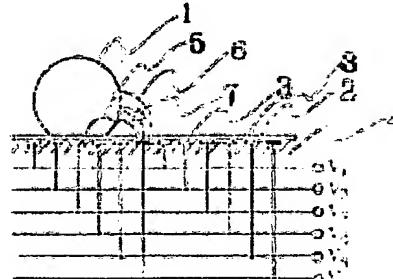
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## (54) HANDLING APPARATUS FOR LIQUID FINE PARTICLE

### (57) Abstract:

**PROBLEM TO BE SOLVED:** To treat liquid fine particles as liquid drops and to transport the liquid fine particles divided and mixed so as to be handled by a method wherein a row of electrodes whose surface is made hydrophobic are installed on a substrate, a sample or a reagent is put on the row of electrodes and a voltage is applied to the row of electrodes.

**SOLUTION:** For example, in a transport operation, a row of six-phase electrodes 3 whose pitch is smaller than a liquid drop 1 are installed on a substrate 4, and a hydrophobic coating 2 is executed onto them. On a hydrophobic surface, the contact angle 5 of the liquid drop 1 becomes larger than 90°. When the surface is hydrophobic, the contact angle 5 becomes large, and the liquid drop 1 becomes a nearly spherical shape like a dewdrop on the leaf of a lotus. When a voltage is applied to one out of the electrodes 3 near the liquid drop 1 in a state that the contact angle 5 is in a state of 90° or higher, a line of electric force 6 is generated across the liquid drop 1 and the electrode 3, and the liquid drop 1 is pulled toward the electrode 3 to which the voltage is applied. When a voltage is applied sequentially to the row of electrodes 3, the liquid drop 1 is transported according to the application of the voltage. The principle of a driving operation is based on an interaction between an electric charge induced in the liquid



drop 1 and an external electrode field, i.e., an induced migration, and the liquid drop 1 is driven irrespective of whether the liquid drop 1 is conductive or not.

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**DETAILED DESCRIPTION****[Detailed Description of the Invention]****[0001]**

[Field of the Invention] This invention relates to a liquid-particulates handling device.

**[0002]**

[Description of the Prior Art] The miniaturized bottom integrates a channel, a reaction vessel, a detector, etc. on one sheet or two or more substrates in recent years. The system called mu-TAS (micro-Total Analysis System) etc. which perform analysis, identification, monitoring, etc. of the chemical introduced from the entrance is going to be put in practical use. In mu-TAS. The technology of \*\* and micromachining structures, such as a channel and a reaction vessel. It not only forms, but it is used effective in fitting of the optical fiber for the detector for measurement of the micropump micro valve for liquid sending, the microheater of a reactor, temperature, a pressure, pH, etc., etc., and optical detection, etc. Since the element of the very thing which constitutes equipment is small, and the whole unifies and it is made, mu-TAS is [ It has the features, like cost can also be made cheap. ] 1. 2 with which the sample and reaction reagent of an analysis object are minute, and can be managed 3 with short time which a reaction takes Reliable 4

**[0003]**

[Problem to be solved by the invention] However, there are some following technical considerations which should be solved in the present proposal and mu-TAS currently developed.

- 1) Since it is a thing of form which pours a sample, a buffer, and a reaction reagent in the continuous channel, the reaction vessel for causing the reaction which has long reaction time, for example serves as inevitability and a long pipe.
- 2) For example, when pouring a sample into a column in an electrophoresis or chromatography at pulse form, a low leak rate and high conductance are required of a valve.

Such a valve is a complicated structure inevitably and serves as the greatest development element for mu-TAS realization.

3) Although the method of controlling pouring of a solution by electroendosmose is also proposed using mere branching as what is replaced with a valve, in this technique, control of leak is difficult.

4) Although it is claimed that dead volume (invalid volume) also becomes minute by microfilming the whole system, although the absolute value becomes small, the rate over the volume of the whole system of reaction does not become small only by scaling down a system as it was.

[0004]

[Means for solving problem] In this invention, it uses that the liquid placed on the canal surface serves as droplet of the form near a globular form, a sample and a reagent are dealt with as droplet on the canal surface, this is driven by impressing voltage to an electrode column, and transportation, distribution, mixing, etc. are performed.

[0005]

[Working example] Drawing 1 is working example of transportation of droplet by a particle handling device of this invention. In this example, an electrode column of six phases which took that pitch smaller than a droplet diameter is provided on a substrate, and hydrophobic coating is performed to that upper surface. Droplet generally placed by solid surface contacts the surface with an certain angle of contact decided by the compatibility of the surface and liquid. If the surface is hydrophobicity, an angle of contact will become larger than 90 degrees. If the surface is fully hydrophobicity, an angle of contact will become large, and droplet will serve as a globular form mostly so that openly on a leaf of a lotus. If voltage is impressed to one of the electrodes near the droplet in the state where an angle of contact is larger than 90 degrees, it is generated by line of electric force between droplet and an electrode, and droplet can be drawn near toward an electrode which impressed voltage as the result. If voltage is impressed to an electrode column one by one and it goes, droplet will be conveyed along with this. A principle of a drive is an interaction of an electric charge derived to droplet, and an outside electric field, i.e., dielectrophoresis, and droplet drives irrespective of the conductivity of droplet in a limitation by which an electric charge is derived to droplet. Since the whole particle enters into electric field which an electrode makes when a pitch of an electrode is larger than a droplet diameter, an effective drive cannot be performed.

[0006] When the surface is hydrophilic nature like a metalized electrode or glass, an angle of contact becomes smaller than 90 degrees, droplet spreads in the shape of a lens on the surface, and effective driving force is not obtained. That is, an effective drive is acquired only in a hydrophobic surface of this invention. Coating by surface fluorocarbon-izing or alkylation, paraffin, or wax using surface Teflon coating and the Silang coupler as a means for acquiring

sufficient hydrophobic surface, etc. are illustrated. If a rugged surface where an aspect ratio is large is processed on the surface like drawing 2, in order that droplet may contact the surface only in the convex upper part, an interaction with the surface becomes smaller and a drive becomes easier. In addition, this convex structure has an effect which minimizes adsorption on the surface of a solute in droplet in order to make a touch area small.

[0007]Drawing 3 is working example of distribution of droplet, and equipment of fusion by a particle handling device of this invention. This equipment consists of an electrode column of 2 sets of 12 phases shown by A and B which can impress voltage independently, and a slot for guiding droplet. As the technique of creating this equipment, a photopolymer is applied for a metallic foil vapor-deposited on a glass substrate from patterning and on its by photo lithography, a guide groove is formed by photo lithography, and the technique of finally performing amorphous Teflon coating to the whole, etc. are illustrated. A guide groove which starts in the port Z branches in an apparatus center, and is connected with the ports X and Y. Droplet put on the port Z is led to the port X or Y by exciting either electrode column of A and B one by one in order of the electrodes 1-12. On the contrary, by exciting an electrode column of A and B both in order of the electrodes 12-1, by a branching portion, droplet put on the ports X and Y contacts, and is united.

[0008]Drawing 4 is the example which applied the transportation, distribution, and fusion by a particle handling device which becomes above-mentioned this invention to a microchemistry reaction apparatus. In this example, after adding two kinds of reaction reagents to a sample solution drop introduced from an entrance, it leads to any of an exit which exists two they are. Since they will be easily united if droplets are contacted, mixing of a sample and a reagent is performed by contacting droplet in a juncture of two passages. What is necessary is to suspend switching of voltage impressed to an electrode and just to only neglect it, after adding a reagent in performing a reaction which time requires. If branching which was illustrated by drawing 2 is made, droplet can be distributed to one of passages. Since a sample and a reagent are treated as independent droplet, there is no possibility that leak and unnecessary mixing of a sample and a reagent may arise.

[0009]Although minute droplet evaporates easily, evaporation can be easily prevented by attaching suitable covering for the passage of droplet and making it closing structure. When the section of a pipeline is smaller than droplet, as shown in a figure, droplet changes, but since a larger angle of contact than 90 degrees will be formed in droplet and the surface if a line inner surface is hydrophobicity such even case, there is no change in the effect of the drive by the electric field which become this invention.

[0010]

[Effect of the Invention]According to the liquid-particulates handling device by this invention, structure is easy, The microchemistry reaction and analysis apparatus which has the feature

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**DESCRIPTION OF DRAWINGS**

[Brief Description of the Drawings]

[Drawing 1]It is a figure showing working example of transportation of the droplet by the particle handling device of this invention.

[Drawing 2]It is a figure showing the canal surface which has a rugged surface in the surface.

[Drawing 3]It is a figure showing working example of distribution of droplet, and the equipment of fusion by this invention.

[Drawing 4]It is a figure showing the microchemistry reaction apparatus by this invention.

[Drawing 5]It is a figure showing the pipeline type droplet transport apparatus by this invention.

[Explanations of letters or numerals]

- 1 Droplet
- 2 Hydrophobic surface coating
- 3 Electrode
- 4 Substrate
- 5 Angle of contact
- 6 Line of electric force
- 7 Driving force
- 8 Hydrophobic rugged surface
- 9 Droplet guide groove
- 10 Port Z
- 11 Port X
- 12 Port Y
- 13 Electrode column A
- 14 Electrode column B
- 15 Electrode A1

- 16 Electrode A12
- 17 Electrode B1
- 18 Electrode B12
- 19 Sample solution drop entrance
- 20 Reagent solution drop entrance 1
- 21 Reagent solution drop entrance 2
- 22 Fusion field 1
- 23 Fusion field 2
- 24 Exit A
- 25 Exit B
- 26 Pipeline
- 27 Droplet which changed

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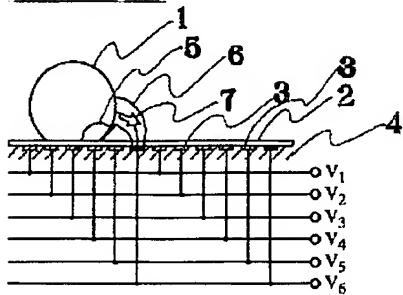
that what is necessary is just to only neglect droplet are realizable also to the reaction which there is no dead volume, a pump valve is also unnecessary, and neither mixing of a sample and a reagent nor the problem of leak also has, and requires a long time.

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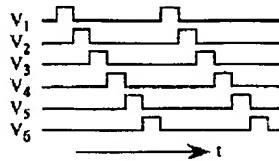
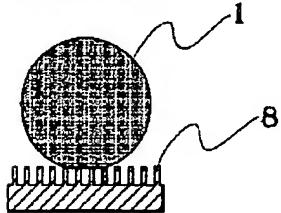
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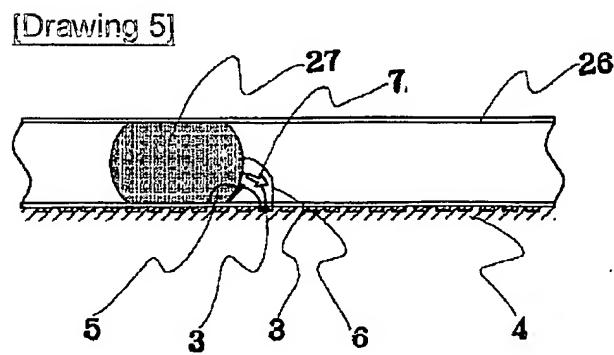
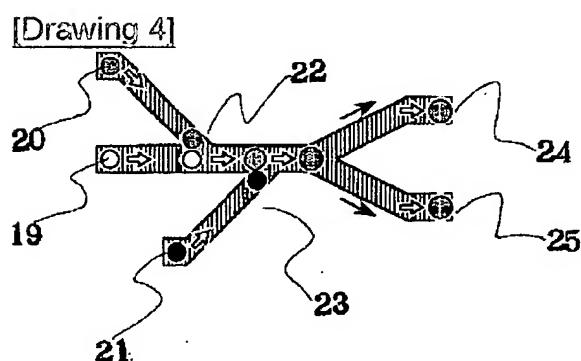
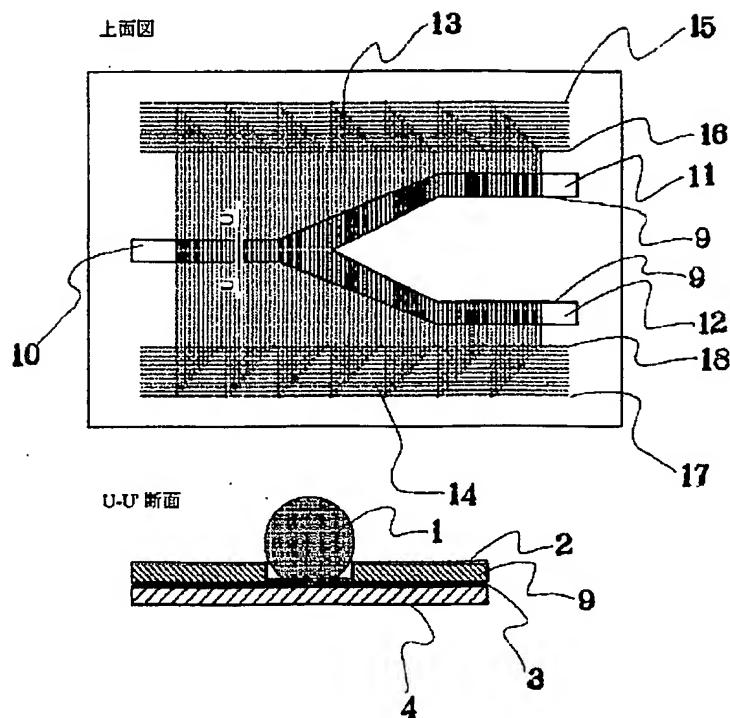
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**DRAWINGS****[Drawing 1]**

タイミングチャート

**[Drawing 2]****[Drawing 3]**



[Translation done.]